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AUTHOR Finn, Michael G.; Bain, Trevor
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ABSTRACT

Presented is an analysis of the education, training, and age distribution of experienced scientists, engineers, energy-related scientists, and energy-related engineers. Data are from the 1976 National Survey of Natural and Social Scientists and Engineers, which is one of a series of longitudinal studies of 50,000 scientists in the labor force at the time of the 1970 Census. Data are presented in tabular form and similarities and differences between energy-related scientists and engineers and others in the same professional fields are identified. (Author/WB)

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Educational and Demographic Characteristics of Energy-Related Scientists and Engineers, 1976

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Prepared by:
Michael G. Finn and Trevor Bain
Oak Ridge Associated Universities
Oak Ridge, Tennessee 37830
Under Contract No. EY-76-C-05-0033

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ABSTRACT

This analysis of the education, training, and age distribution of experienced scientists, engineers, energy-related scientists, and energy-related engineers uses the 1976 National Science Foundation National Sample data on 50,000 scientists and engineers who were in the labor force at the time of the 1970 Census. The energy-related scientists and engineers have characteristics quite similar to those of all scientists and engineers. However, energy-related scientists and engineers report slightly higher educational attainment as well as a higher incidence of supplemental training. Energy-related engineers generally are not much older than their counterparts who did not report energy-related work. Energy-related scientists, however, are older than their counterparts and can be expected to experience losses from death and retirement at a rate about 12 percent higher than the rate for all scientists over the next decade.

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SECTION 1 - INTRODUCTION

This report examines the educational and demographic characteristics of energy-related scientists and engineers. In particular, an attempt is made to identify similarities and differences between the energy-related scientists and engineers and others in the same professional fields. In some instances, those differences are explored for public policy implications. For example, energy-related scientists tend to be older than other scientists, so the implications for projections of retirement and replacement demand are examined.

This report is selective rather than exhaustive in its treatment of educational and demographic characteristics. This selectivity is prompted by the fact that the data set contains only experienced scientists and engineers, i.e., those who were in the labor force in 1970. Thus, certain issues (e.g., the changing sex composition of the science and engineering labor force) are not discussed.

DATA

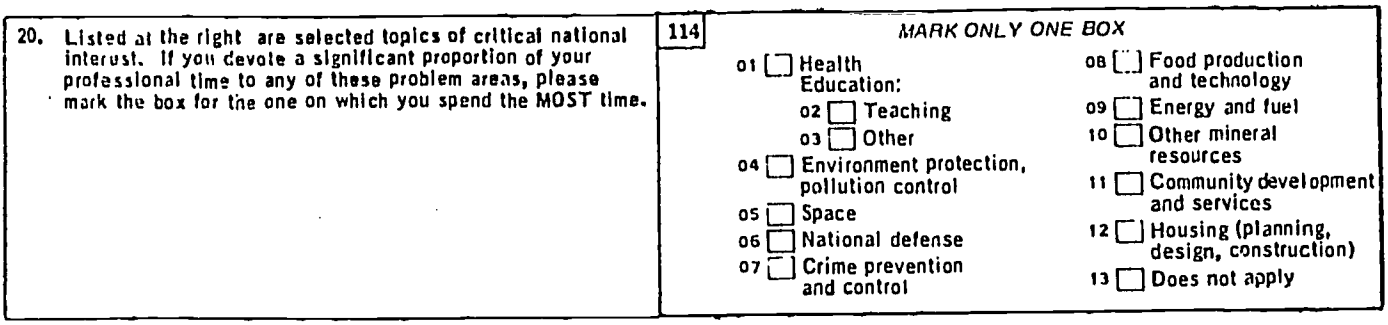
All the data in this report come from the Public Use Tapes of the 1976 National Survey of Natural and Social Scientists and Engineers. The survey was conducted by the Bureau of the Census for the National Science Foundation (NSF). It is one in a series of surveys of about 50,000 scientists and engineers who were initially selected for these surveys on the basis of their response to the 1970 Census of Population. The data set is longitudinal: It follows a national sample of scientists and engineers over a period of several years. This feature of the data set carries with it a limitation, however: Because persons entering the labor force since 1970 are not included, the data presented here cannot be assumed to be representative of all scientists and engineers.

Another feature of the NSF data presented here is that scientists and engineers are classified into scientific and engineering fields not by reported occupation or by degree field but by criteria that use occupation of employment, major field of study for highest degree, and other information to classify scientists and engineers by professional field. For

example, a person working as an administrator may be classified as an engineer if his highest degree is in engineering and if he considers engineering to be his profession.[1]

DEFINING ENERGY-RELATED SCIENTISTS AND ENGINEERS

In this report, *energy-related* scientists and engineers are defined as persons who indicated in the survey that they devoted a significant portion of their professional time to the energy problem, one of several critical national interest problem areas from which respondents could choose. (The actual question from the 1976 survey is reproduced as Figure 1.)



20. Listed at the right are selected topics of critical national interest. If you devote a significant proportion of your professional time to any of these problem areas, please mark the box for the one on which you spend the MOST time.

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MARK ONLY ONE BOX

- 01 ☐ Health
- Education:
  - 02 ☐ Teaching
  - 03 ☐ Other
- 04 ☐ Environment protection, pollution control
- 05 ☐ Space
- 06 ☐ National defense
- 07 ☐ Crime prevention and control
- 08 ☐ Food production and technology
- 09 ☐ Energy and fuel
- 10 ☐ Other mineral resources
- 11 ☐ Community development and services
- 12 ☐ Housing (planning, design, construction)
- 13 ☐ Does not apply

Source: U. S. Bureau of the Census/NSF, *1976 National Survey of Natural and Social Scientists and Engineers.*

Figure 1. Question Used To Identify Energy-Related Scientists and Engineers from the 1976 National Sample.

Note that the question permits respondents to select only one of the topics mentioned. Therefore, some of the persons working on the health or environmental effects of energy production can be expected to have chosen "health" or "environment protection, pollution control" instead of "energy and fuel." In effect, what results from a tabulation of persons who selected "energy and fuel" might be accurately described as the core group of energy-related manpower because it excludes persons who perceive their work to be more closely related to one of the other problem areas, even though their work might also be energy-related.

SECTION 2 - EDUCATIONAL CHARACTERISTICS

This section examines three aspects of the educational characteristics of energy-related scientists and engineers:

1. Their formal education defined as degree attainment
2. Training defined as non-degree courses and programs
3. The relationship between current occupation and field of formal education

The approach was, first, to identify those professional fields where the proportion engaged in energy-related work was above average. Then, for these fields, the characteristics of energy-related scientists and engineers were compared with the characteristics of all scientists and engineers. The principal objective was to determine whether energy-related scientists and engineers differ from all scientists and engineers in ways that have implications for public policy.

IDENTIFICATION OF ENERGY-RELATED FIELDS

Overall, 11.2 percent of all the scientists and engineers reported that their work was energy-related (Table 2-1). Since the description and analysis is always conducted in terms of specific professional fields, it is useful to focus on those fields where the proportion of energy-related scientists and engineers is at or above the 11.2 percent average. These are referred to as *energy-related* fields. There are eight: physics and astronomy (14.1 percent), earth science (47.9 percent), chemical engineering (23.0 percent), mechanical engineering (17.9 percent), metallurgical and materials engineering (14.8 percent), mining and petroleum engineering (66.4 percent), nuclear engineering (65.3 percent), and managerial and administrative engineering (14.9 percent).

FORMAL EDUCATION

The level of educational attainment is high among engineers and scientists. There is no consistent overall pattern for higher or lower educational attainment of energy-related engineers and scientists. Tables 2-2 and 2-3 show data on degree levels for those fields defined as energy-related by the criterion mentioned above. Overall, energy-related scientists reported the Ph.D. degree less often than all scientists (35.6 percent versus 40.8 percent). However, this is because the total of energy-related scientists in these tables is made up largely of earth scientists, the only field where the Ph.D. is not more common among the energy-related.

Table 2-1. Professional Field, Total vs. Energy-Related Scientists and Engineers, 1976

Field	Total	Energy-Related	Percent Energy-Related
Total, scientist and engineer	1,029,025	114,895	11.2%
Scientist	369,184	26,708	7.2
Mathematician and statistician	24,976	851	*
Computer specialist	50,290	2,592	5.2
Physical scientist	117,100	10,560	9.0
Chemist	83,840	5,991	7.2
Physicist, astronomer	27,506	3,889	14.1
Other physical scientist	5,754	680	*
Environmental, earth, and marine scientist	26,982	10,845	40.2
Earth scientist (geologist and geophysicist)	22,372	10,721	47.9
Atmospheric and marine scientist	4,610	124	*
Life scientist	70,094	438	*
Psychologist	34,195	229	*
Social scientist	45,547	1,193	2.6
Economist	17,700	975	*
Other social scientist	27,847	218	*
Engineer	659,841	88,187	13.4
Chemical	37,165	8,543	23.0
Civil and architectural	86,583	6,084	7.0
Electrical and electronic	135,240	15,066	11.1
Mechanical	125,159	22,382	17.9
Metallurgical and materials	15,691	2,324	14.8
Mining and petroleum	10,813	7,178	66.4
Nuclear	5,391	3,519	65.3
Managerial and administrative	74,637	11,130	14.9
Environmental and sanitary	9,424	150	*
Operations research and systems	12,137	1,262	10.4
Industrial	28,095	1,897	6.8
Other	119,506	8,652	7.2

Source: U. S. Bureau of the Census/NSF, *1976 National Survey of Natural and Social Scientists and Engineers.*

*No percentage is calculated in cases where the number of energy-related is fewer than 1000.

Table 2-2. Educational Distribution of Scientists and Engineers, 1976

Professional Field	Bachelor's	Master's	Ph.D.	Other
Total, scientist	34.1%	24.5%	40.8%	0.6%
Physicist, astronomer	16.8	19.3	63.9	--
Earth scientist (includes geologist and geophysicist)	46.2	27.8	26.0	--
Total, Engineer	68.7	21.8	5.1	4.4
Chemical	61.5	24.7	13.4	0.4
Mechanical	70.9	20.1	4.0	5.0
Metallurgical and materials	58.0	21.9	17.2	2.9
Mining and petroleum	79.3	15.0	4.8	0.9
Nuclear	44.8	43.6	11.6	--
Managerial and administrative	73.1	22.5	4.1	0.2

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

Table 2-3. Educational Distribution of Energy-Related Scientists and Engineers, 1976

Professional Field	Bachelor's	Master's	Ph.D.	Other
Total, scientist	39.3%	25.1%	35.6%	--
Physicist, astronomer	15.0	11.6	73.4	--
Earth scientist (includes geologist and geophysicist)	51.8	31.4	16.8	--
Total, engineer	68.5	22.5	6.7	2.3%
Chemical	53.4	27.9	18.3	0.4
Mechanical	70.6	21.6	5.3	2.5
Metallurgical and materials	49.1	26.5	19.0	5.4
Mining and petroleum	76.4	17.5	5.3	0.8
Nuclear	41.1	46.1	12.8	--
Managerial and administrative	74.2	21.1	4.7	--

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

Among engineers, the energy-related reported a higher level of educational attainment. For example, 6.7 percent of energy-related engineers reported the Ph.D. degree compared with 5.1 percent of all engineers, and in every field examined the proportion of Ph.D.'s was larger among the energy-related engineers.

COLLEGE MAJOR AND CURRENT OCCUPATION

This section examines the relationship between the current professional fields of scientists and engineers and their major fields of study in college. It is important to note that the data presented here can sometimes be interpreted in quite different ways, and it is not always possible to know which interpretation is correct by using only the data presented here. For example, the data show that a significant number of engineers received their highest degree in a field other than engineering. We can imagine some very different hypotheses to explain this. One is that there may be a high degree of skill transferability between certain nonengineering fields of study and some engineering fields. For example, a chemistry major with the right mix of college courses might be as well qualified for a particular chemical engineering job as many of the persons who majored in chemical engineering. Alternatively, it may be that the person with a nonengineering major is not so well trained for an engineering job but was hired because of a shortage of qualified engineers. Both of these situations would indicate some degree of transferability between fields. However, another explanation, undoubtedly applicable in some cases, does not imply transferability of skills: A person with a bachelor's degree in engineering may take a master's degree in a field that is expected to help in his career precisely by helping him to move out of engineering work. The most obvious example is graduate study in business administration. This is probably best viewed as a complement to engineering education, not as a substitute. Thus, one must be careful not to misread the data by inferring easy transferability between fields, when in fact the better explanation may be complementary study. Table 2-4 summarizes the data for the highest degrees attained.

In examining the data on field of study of those whose highest degree is the bachelor's degree (Table 2-5), it is noted that one of the extreme cases is probably due to peculiarities in the NSF data. The field of

Table 2-4. Professional Field and College Major, Total vs. Energy-Related Scientists and Engineers with a Bachelor's Degree or Higher, 1976

Professional Field	Percentage Majoring in*							
	Engineering		Physical Sciences		Biological and Agri. Sciences		Business	
	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related
Scientist								
Physicist, astronomer	2.4%	4.3%	94.6%	93.5%				
Earth scientist	5.0	5.1	85.4	87.9	3.4%	0.8%		
Engineer								
Chemical	88.0	93.7	6.1	3.7			2.2%	0.9%
Mechanical	92.5	92.6					2.6	3.4
Metallurgical and materials	82.5	85.2	10.4	10.9			2.2	2.2
Mining and petroleum	83.2	84.7	11.2	8.4			1.3	1.5
Nuclear	77.3	75.9	11.7	11.3			4.2	4.9
Managerial and administrative	98.4	99.0	1.1	.2				

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

*Field of study refers to highest degree held. Data not reported under 1.0 percent.

Table 2-5. Professional Field and College Major, Total vs. Energy-Related Scientists and Engineers with a Bachelor's Degree, 1976

Professional Field	Percentage Majoring in*									
	Engineering		Physical Sciences		Biological and Agri. Sciences		Business		Mathematical Sciences	
	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related
Scientist										
Physicist, astronomer	3.8%	6.3%	91.3%	89.4%					2.7%	2.2%
Earth scientist	7.5	7.7	82.5	84.6	3.7%	0			3.2	5.1
Engineer										
Chemical	89.6	95.8	7.0	3.1						
Mechanical	94.3	94.7								
Metallurgical and materials	82.2	81.8	11.1	15.1	1.9	0				
Mining and petroleum	85.7	86.7	10.2	7.6						
Nuclear	84.2	80.0	9.1	8.8			2.2%	3.6%		
Managerial and administrative	98.8	99.8	1.0							

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

*Field of study refers to highest degree held. Data not reported under 1.0 percent.

engineering with the highest proportion having majored in engineering (98.8 percent) is the managerial/administrative field. The explanation of this is in the NSF criteria: Persons working as managers are not likely to be counted as engineers unless they have a degree in engineering. In the other five engineering fields examined, the proportion of persons whose degrees were in engineering ranged from a low of 82.2 percent for metallurgical and materials engineers to a high of 94.3 percent for mechanical engineers. Most of the engineers with degrees outside engineering had degrees in physical science. Among the bachelor's-level scientists, 91.3 percent of the physicists and 82.5 percent of the earth scientists reported a college major in physical science. At the bachelor's degree level, there is no clear pattern of the energy-related respondents having majored in their professional field more or less often than the total.

Among master's degree holders, the pattern is different, in large part because of engineers receiving MBAs (Table 2-6). While these data show significant numbers of engineers with master's degrees in business, they are not designed to include all engineers who have gone on to business careers; the proportion of MBAs would undoubtedly be much higher if such were the case.[2] There is no consistent pattern for the energy-related respondents to have majored in their professional field more or less often than the total.

At the Ph.D. level, we observe a rather mixed pattern (Table 2-7). In those fields that are most energy-related (nuclear engineering and mining and petroleum engineering), there are high proportions (27.2 and 31.6 percent, respectively) reporting they received their Ph.D. degrees in the physical sciences rather than engineering. In other engineering fields, the proportion receiving the Ph.D. in a nonengineering field is much smaller. It is worth noting that the same phenomenon appears in data from a different survey.[3]

The Ph.D. recipients who reported that their work was energy-related had educational backgrounds that were very similar to their Ph.D. counterparts who did not report that their work was energy-related.

Table 2-6. Professional Field and College Major, Total vs. Energy-Related Scientists and Engineers with a Master's Degree, 1976

Professional Field	Percentage Majoring in*							
	Engineering		Physical Sciences		Business		Mathematical Sciences	
	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related
Scientist								
Physicist, astronomer	2.9%	2.5%	92.1%	91.6%				
Earth scientist	1.8	1.6	89.4	91.9				
Engineer								
Chemical	81.7	90.1	4.9	5.7	8.4%	3.2%		
Mechanical	85.5	84.0			9.3	13.1	1.0%	1.5%
Metallurgical and materials	81.0	90.1	8.8	2.0	7.2	6.0		
Mining and petroleum	75.3	80.1	9.6	6.5	7.9	7.4		
Nuclear	71.9	73.8	10.3	9.3	7.4	7.5		
Managerial and administrative	97.3	96.9	1.7	.5	.4	2.6		

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

*Field of study refers to highest degree held. Data not reported under 1.0 percent.

Table 2-7. Professional Field and College Major, Total vs. Energy-Related Scientists and Engineers with a Ph.D., 1976

Professional Field	Percentage Majoring in*									
	Engineering		Physical Sciences		Biological and Agri. Sciences		Psychology		Mathematical Sciences	
	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related	Total	Energy-Related
Scientist										
Physicist, astronomer	1.8%	3.8%	96.2%	94.6%						
Earth scientist	3.7	3.7	86.3	90.7	4.4%	3.6%				
Engineer										
Chemical	91.9	93.2	3.9	2.3	1.3	2.3				
Mechanical	95.6	100.0	2.3	0			1.1%	0		
Metallurgical and materials	88.5	87.3	10.0	12.7						
Mining and petroleum	66.1	71.5	31.6	25.4						
Nuclear	70.7	70.4	27.2	26.8					2.1%	2.9%
Managerial and administrative	98.8	95.2	.4	2.3						

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

*Field of study refers to highest degree held. Data not reported under 1.0 percent.

TRAINING

How often do scientists and engineers receive training? What types of training programs do they participate in? Do energy-related scientists and engineers receive the same or different training? Have there been any significant changes in the types of training received in the past few years? These are the questions addressed in this section.

The training described here excludes formal degree programs; it is of a more informal nature and falls into one of the following categories:

1. On-the-job training
2. Military training applicable to civilian occupations
3. Extension or correspondence courses
4. Courses at employer's training facility
5. Courses at adult education center
6. Other training

Training is not a one-time event for engineers and scientists. It is something they undertake repeatedly. For example, when the engineers in the sample were queried in 1972, some 68 percent reported they had received supplemental training. When queried again in 1974, some 47 percent reported additional training since the 1972 survey. Finally, in 1976, the same engineers were questioned again, and 45 percent reported they had received training since the 1974 survey. The pattern for scientists was very similar, although scientists received training a little less frequently.

Although approximately 30 percent of scientists and engineers changed jobs during the 2 years preceding the 1976 survey, the training reported during this period does not appear to be strongly related to job changing activity. About half of the engineers who changed jobs during this period also received training during the period. However, 40 percent of the engineers who did not change jobs reported training as well. Since the latter group (those not changing jobs) is much larger, the majority of the recipients of training are persons who did not change jobs during the period (see Table 2-8). Thus, it can be concluded that the primary use of training is for updating and upgrading the skills of persons who have not experienced a significant change in job duties.

Table 2-8. Education and Training Received by Scientists and Engineers, 1974 and 1975

	Total			Energy-Related		
	Number	Percent Receiving Education During 1974-75	Percent Receiving Training During 1974-75	Number	Percent Receiving Education During 1974-75	Percent Receiving Training During 1974-75
Total, scientist	369,184	3.0%	40.6%	26,708	3.5%	44.4%
Same job, 1974-76	233,519	1.9	39.5	15,280	.8	42.9
Two or more jobs, 1974-76	86,507	6.8	50.3	8,061	8.8	51.1
No information on job change, 1974-76	49,158	1.6	28.8	3,367	2.3	42.6
Total, engineer	659,841	2.0	44.5	88,187	2.4	53.5
Same job, 1974-76	396,412	1.7	44.7	52,826	1.9	51.3
Two or more jobs, 1974-76	157,065	2.8	55.4	26,763	3.6	59.8
No information on job change, 1974-76	106,364	1.6	27.7	8,598	1.4	47.2

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientist and Engineers*

Two types of training stand out as the most popular and account for two-thirds of all training: on-the-job training and courses at the employer's training facility. There are only minor differences between engineers and scientists in the type of training they received. For example, scientists, more than engineers, generally rely more on on-the-job training and less on courses at an employer's training facility. Tables 2-9 and 2-10 summarize data and the tables in the Appendix detail the data on training by field. Because data for training received during 1974 were examined and found to be nearly identical to those for 1975, the latter were used in the detailed tables.*

When energy-related engineers are compared with all engineers, the percentages engaged in training within these two groups were greater for the energy-related engineers for all types of training (the percentages for military training were the same). When energy-related scientists are compared with all scientists, the percentages engaged in training within the two groups were greater in only half of the types of training: courses at employer's facility, on-the-job training, and adult education.

Comparing energy-related scientists with energy-related engineers, the scientists reported less training overall and less frequently reported every one of the six kinds of training examined (Table 2-10).

It can be concluded, though, that energy-related scientists and engineers engage in training more frequently than their counterparts who are not involved in energy-related work. There presently is no explanation why the energy-related undertake training more often than others. One possible explanation that was examined and found not to be a factor is the frequency of job changes. It was found that energy-related engineers did not change jobs any more frequently than did other engineers during the 1974-76 period. Furthermore, those who did change jobs did not report training much more frequently than those who worked at the same job throughout the period.

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*All of the data are from the 1976 survey. The questionnaire for this survey requested information on training received in 1974 and in 1975.

Table 2-9. Type of Training Received by Scientists and Engineers, 1974 and 1975

Type of Training	1974		1975	
	Engineers	Scientists	Engineers	Scientists
On-the-job training	15.7%	16.9%	16.8%	18.0%
Military training applicable to civilian occupations	.7	.5	.8	.6
Extension or correspondence courses	3.4	2.6	3.6	3.3
Courses at employer's training facility	16.8	12.7	17.2	13.9
Courses at adult education center	3.6	3.2	4.1	4.1
Other training	6.4	8.2	7.6	9.9

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

Table 2-10. Type of Training Received by Energy-Related Scientists and Engineers, 1974 and 1975

Type of Training	1974		1975	
	Engineers	Scientists	Engineers	Scientists
On-the-job training	19.9%	18.4%	19.9%	18.7%
Military training applicable to civilian occupations	.7	.3	.7	.3
Extension or correspondence courses	3.6	2.6	4.0	2.6
Courses at employer's training facility	21.9	17.9	20.9	17.5
Courses at adult education center	4.3	3.7	4.6	4.3
Other training	8.4	7.1	11.0	9.0

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

SECTION 3 - DEMOGRAPHIC CHARACTERISTICS

This section examines four demographic characteristics of energy-related scientists and engineers (the analysis includes 23 professional fields rather than the 9 energy-related fields discussed in the previous section):

1. Age distribution of all scientists and engineers by professional field
2. Age distribution of energy-related scientists and engineers
3. Relative proportions of scientists and engineers in each professional field under 40 years of age contrasted with those 45 years of age or older, to measure whether the field is young or old
4. Separation of scientists and engineers in the sample from the labor force between 1976 and 1985.

An examination of the age distribution for all scientists and engineers reveals the following distribution (see Table 3-1):

1. Chemical engineers had a somewhat bimodal age distribution: 40.0 percent were under 40, and 53.1 percent were 45 or older. It can be concluded that most chemical engineers are at least middle-aged.
2. Mechanical engineers tended to be middle-aged with 35.8 percent under 40, and 52.0 percent 45 or older.
3. Metallurgical engineers were among the oldest with 31.7 percent under 40, and 56.4 percent 45 or older.
4. Mining and petroleum engineers had the oldest age distribution of all scientists and engineers: only 20 percent were under 40; 63.4 percent were 45 or older.
5. Nuclear engineers were among the youngest: 43.6 percent were under 40, and 40.3 percent were 45 or older.
6. Engineers in management tended to be middle-aged with 29.7 percent under 40, and 51.7 percent 45 or older.
7. Physicists and astronomers had the youngest age distribution with 45.4 percent under 40, and 37.9 percent 45 or older.

Table 3-1. Professional Field by Age, Total vs. Energy-Related Scientists and Engineers, 1976

Professional Field	Under 25				25-29			
	Total		Energy-Related		Total		Energy-Related	
	No.	%	No.	%	No.	%	No.	%
Total, scientist	69	0			18,162	4.9	1,289	4.8
Mathematician and statistician					1,183	4.7	74	8.7
Computer specialist					4,300	8.6	211	8.1
Physical scientist					4,727	4.0	525	5.0
Chemist					3,074	3.7	206	3.4
Physicist					1,325	4.8	319	8.2
Other physical					328	5.7		
Environmental					937	3.5	413	3.8
Earth					799	3.6	413	3.9
Atmos. and marine					138	3.0		
Life scientist	69	0.1			3,144	4.5		
Psychologist					2,052	6.0	19	8.3
Social scientist					1,819	4.0	47	3.9
Economist					511	2.9	18	1.8
Other social					1,308	4.7	29	13.3
Total, engineer	112	0	15	0	30,562	4.6	5,036	5.7
Chemical					2,201	5.9	485	5.7
Civil					3,973	4.6	408	6.7
Electrical					6,728	5.0	751	5.0
Mechanical	15		15	0.1	7,243	5.8	1,976	8.8
Metallurgical and materials					352	2.2	45	1.9
Mining and petroleum					400	3.7	298	4.2
Nuclear					189	3.5	135	3.8
Managerial and administrative	38	.1			2,174	2.9	218	2.0
Environmental					591	6.3		
Operations research/systems					636	5.2	112	8.9
Industrial					1,394	5.0	230	12.1
Other	59	0			4,681	3.9	378	4.4

Table 3-1. Professional Field by Age, Total vs. Energy-Related Scientists and Engineers, 1976 (Cont'd)

Professional Field	30-34				35-39			
	Total		Energy-Related		Total		Energy-Related	
	No.	%	No.	%	No.	%	No.	%
Total, scientist	71,489	19.4	4,360	16.3	67,274	18.2	3,796	14.2
Mathematician and statistician	5,631	22.5	147	17.3	4,947	19.8	109	12.8
Computer specialist	16,100	32.0	931	35.9	12,721	25.3	739	28.5
Physical scientist	18,683	16.0	1,712	16.2	20,664	17.6	1,755	16.6
Chemist	13,027	15.5	851	14.2	13,214	15.8	990	16.5
Physicist	4,851	17.6	706	18.2	6,313	23.0	670	17.2
Other physical	805	14.0	155	22.8	1,137	19.8	95	14.0
Environmental	2,588	9.6	968	8.9	3,628	13.4	953	8.8
Earth	2,024	9.0	968	9.0	2,811	12.6	939	8.8
Atmos. and marine	564	12.2			817	17.7	14	11.3
Life scientist	11,479	6.4	133	30.4	12,495	17.8	37	8.4
Psychologist	7,041	20.6	64	27.9	5,894	17.2		
Social scientist	9,967	21.9	405	33.9	6,925	15.2	203	17.0
Economist	3,201	18.1	387	39.7	2,527	14.3	158	16.2
Other social	6,766	24.3	18	8.3	4,398	15.8	45	20.6
Total, engineer	83,184	12.6	13,280	15.1	101,734	15.4	14,187	16.1
Chemical	5,605	15.1	1,247	14.6	5,583	15.0	1,374	16.1
Civil	9,058	10.5	770	12.7	14,376	16.6	1,096	18.0
Electrical	20,149	14.9	3,123	20.7	21,660	16.0	2,282	15.1
Mechanical	16,200	12.9	3,375	15.1	18,708	14.9	3,618	16.2
Metallurgical and materials	1,911	12.2	286	12.3	2,718	17.3	447	19.2
Mining and petroleum	742	6.9	585	8.1	1,017	9.4	759	10.6
Nuclear	1,068	19.8	558	15.9	1,097	20.3	782	22.2
Managerial and administrative	7,444	10.0	1,118	10.0	12,643	16.9	1,865	16.8
Environmental	1,811	19.2	63	42.0	1,932	20.5	13	8.7
Operations research/systems	2,386	19.7	255	20.2	2,603	21.4	472	37.4
Industrial	3,350	11.9	212	11.2	3,890	13.8	229	12.1
Other	13,460	11.3	1,688	19.5	15,507	13.0	1,250	14.4

Table 3-1. Professional Field By Age, Total vs. Energy-Related Scientists and Engineers, 1976 (Cont'd)

Professional Field	40-44				45-49			
	Total		Energy-Related		Total		Energy-Related	
	No.	%	No.	%	No.	%	No.	%
Total, scientist	56,632	15.3	4,044	15.1	50,311	13.6	4,772	17.9
Mathematician and statistician	3,827	15.3	105	12.3	3,587	14.4	165	19.4
Computer specialist	8,234	16.4	257	9.9	4,814	9.6	279	10.8
Physical scientist	17,937	15.3	1,452	13.8	15,909	13.6	1,338	12.7
Chemist	12,351	14.7	806	13.5	11,390	13.6	582	9.7
Physicist	4,614	16.8	572	14.7	3,675	13.4	640	16.5
Other physical	972	16.9	74	10.9	844	14.7	116	17.1
Environmental	5,094	18.9	2,061	19.0	5,227	19.4	2,566	23.7
Earth	4,339	19.4	2,010	18.7	4,639	20.7	2,531	23.6
Atmos. and marine	755	16.4	51	41.1	588	12.8	35	23.2
Life scientist	11,068	15.8	37	8.4	9,944	14.2	85	19.4
Psychologist	4,661	13.6	13	5.7	5,055	14.8	121	52.8
Social scientist	5,811	12.8	119	10.0	5,775	12.7	218	18.3
Economist	2,092	11.8	89	9.1	2,172	12.3	167	17.1
Other social	3,719	13.4	30	13.8	3,603	12.9	51	23.4
Total, engineer	99,582	15.1	12,660	14.4	102,824	15.6	13,411	15.2
Chemical	4,064	10.9	1,005	11.8	4,721	12.7	1,265	14.8
Civil	12,952	15.0	895	14.7	13,227	15.3	772	12.7
Electrical	23,302	17.2	2,030	13.5	22,779	16.8	2,427	16.1
Mechanical	16,934	13.5	2,713	12.1	19,007	15.2	3,188	14.2
Metallurgical and materials	1,868	11.9	450	19.4	2,118	13.5	326	14.0
Mining and petroleum	1,797	16.6	1,297	18.1	1,814	16.8	1,373	19.1
Nuclear	865	16.0	554	15.7	537	10.0	197	5.6
Managerial and administrative	13,881	18.6	1,920	17.3	13,594	18.2	2,408	21.6
Environmental	1,095	11.6	74	49.3	932	9.9		
Operations research/systems	1,640	13.5	99	7.8	2,448	20.2	82	6.5
Industrial	4,572	16.3	300	15.8	4,302	15.3	240	12.7
Other	16,612	13.9	1,323	15.3	17,345	14.5	1,133	13.1

Table 3-1. Professional Field by Age, Total vs. Energy-Related Scientists and Engineers, 1976 (Cont'd)

Professional Field	50-54				55-59			
	Total		Energy-Related		Total		Energy-Related	
	No.	%	No.	%	No.	%	No.	%
Total, scientist	40,865	11.1	3,938	14.7	29,058	7.9	2,127	8.0
Mathematician and statistician	2,085	8.3	119	14.0	1,580	6.3	70	8.2
Computer specialist	2,361	4.7	94	3.6	1,176	2.3	65	2.5
Physical scientist	14,811	12.6	1,489	14.1	10,785	9.2	948	9.0
Chemist	11,411	13.6	1,108	18.5	8,700	10.4	655	10.9
Physicist	2,717	9.9	286	7.4	1,516	5.5	229	5.9
Other physical	683	11.9	95	14.0	569	9.9	64	9.4
Environmental	3,753	13.9	2,061	19.0	2,962	11.0	943	8.7
Earth	3,278	14.7	2,049	19.1	2,144	9.6	943	8.8
Atmos. and marine	475	10.3	12	9.7	818	17.7		
Life scientist	8,274	11.8	63	14.4	6,099	8.6	58	13.2
Psychologist	4,338	12.7			2,248	6.6		
Social scientist	5,243	11.5	112	9.4	4,208	9.2	43	3.6
Economist	2,651	15.0	80	8.2	1,617	9.1	43	4.4
Other social	2,592	9.3	32	14.7	2,591	9.3		
Total, engineer	101,482	15.4	14,240	16.1	62,252	9.4	7,856	8.9
Chemical	5,560	15.0	1,112	13.0	5,162	13.9	1,230	14.4
Civil	12,491	14.4	594	9.8	6,474	7.5	500	8.2
Electrical	18,912	14.0	2,197	14.6	10,572	7.8	937	6.2
Mechanical	22,118	17.7	3,726	16.6	12,583	10.1	1,964	8.8
Metallurgical and materials	2,789	17.8	312	13.4	1,801	11.5	261	11.2
Mining and petroleum	2,367	21.9	1,650	23.0	1,026	9.5	551	7.7
Nuclear	896	16.6	793	22.5	441	8.2	391	11.1
Managerial and administrative	11,996	16.1	1,800	16.2	7,370	9.9	888	8.0
Environmental	1,355	14.4			647	6.9		
Operations research/systems	1,005	8.3	78	6.2	1,001	8.2	164	13.0
Industrial	4,258	15.2	408	21.5	3,330	11.9	163	8.6
Other	17,735	14.8	1,570	18.1	11,845	9.9	807	9.3

Table 3-1. Professional Field by Age, Total vs. Energy-Related Scientists and Engineers, 1976 (Cont'd)

Professional Field	60-64				65 & over			
	Total		Energy-Related		Total		Energy-Related	
	No.	%	No.	%	No.	%	No.	%
Total, scientist	18,439	5.0	1,796	6.7	16,995	4.6	586	2.2
Mathematician and statistician	1,105	4.4	62	7.3	1,031	4.1		
Computer specialist	367	.7			217	.4	16	.6
Physical scientist	7,396	6.2	1,049	9.9	6,298	5.4	292	2.8
Chemist	5,763	6.9	581	9.7	4,910	5.9	212	3.5
Physicist	1,267	4.6	400	10.3	1,228	4.5	67	1.7
Other physical	256	4.4	68	10.0	160	2.8	13	1.9
Environmental	1,478	5.5	615	5.7	1,315	4.9	265	2.4
Earth	1,191	5.3	603	5.6	1,147	5.1	265	2.5
Atmos. and marine	287	6.2	12	9.7	168	3.6		
Life scientist	4,109	5.9	12	2.7	3,413	4.9	13	3.0
Psychologist	1,378	4.0	12	5.2	1,528	4.5		
Social scientist	2,606	5.7	46	3.9	3,193	7.0		
Economist	1,185	6.7	33	3.4	1,744	9.9		
Other social	1,421	5.1	13	6.0	1,449	5.2		
Total, engineer	40,063	6.1	5,552	6.3	38,046	5.8	1,950	2.2
Chemical	2,867	7.7	607	7.1	1,402	3.8	218	2.6
Civil	5,343	6.2	602	9.9	8,689	10.0	447	7.3
Electrical	6,422	4.7	885	5.9	4,716	3.5	434	2.9
Mechanical	7,504	6.0	1,386	6.2	4,847	3.9	421	1.9
Metallurgical and materials	1,424	9.1	173	7.4	710	4.5	24	1.0
Mining and petroleum	1,051	9.7	404	5.6	599	5.5	261	3.6
Nuclear	163	3.0	109	3.1	135	2.5		
Managerial and administrative	3,271	4.4	864	7.8	2,226	3.0	49	.4
Environmental	638	6.8			423	4.5		
Operations research/systems	310	2.6			108	.9		
Industrial	1,978	7.0	115	6.1	1,021	3.6		
Other	9,092	7.6	407	4.7	13,170	11.0	96	1.1

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Enginee*

NOTE: Blank spaces indicate data is unavailable.

8. Earth scientists had the oldest age distribution of the scientists with 25.2 percent under 40, and 55.4 percent 45 or older.

All scientists and engineers tended to be middle-aged except for nuclear engineers and physicists, the only fields examined where the majority of respondents were less than 45 years old. It is useful to recall that we are examining the population of experienced scientists and engineers, not a representative sample of all engineers and scientists. The age distribution of mining and petroleum engineers reflects the previously limited market and small demand for these fields of engineering with demand exceeding supply only in the past couple of years.

An examination of the age distribution of energy-related scientists and engineers reveals the following (see Table 3-1):

1. Chemical engineers tended to be middle-aged with 36.4 percent under 40, and 51.9 percent 45 or older.
2. Mechanical engineers had a fairly even age distribution with 40.2 percent under 40, and 47.7 percent 45 or older. Mechanical engineers were younger than most of the engineers in other fields.
3. Mining and petroleum engineers were middle-aged with only 22.9 percent under 40; 59 percent were 45 or older.
4. Nuclear engineers had a fairly even age distribution with 41.9 percent under 40, and 42.3 percent 45 or older.
5. Engineers in management doing energy-related work were slightly older than all scientists and engineers with 28.8 percent under 40, and 54 percent 45 or older.
6. Physicists had a young age distribution with 43.6 percent under 40, and 41.8 percent 45 or older.
7. Earth scientists were middle-aged with 21.7 percent under 40, and 59.6 percent 45 or older.

Generally, engineers working in energy-related tasks were younger than their counterparts in nonenergy-related work. The exception was nuclear engineering. Management engineers and scientists in energy-related work, however, were older than their counterparts in nonenergy-related work. These conclusions are relative. In absolute terms, scientists and engineers both in and out of energy-related work were middle-aged.

The number of job openings for new scientists and engineers in the future is a function of two distinct factors: growth in total demand and replacement needs. Replacement needs are usually understood by analysts to arise from either occupational mobility or actual separation from the labor force due to death or retirement. Occupational mobility is not treated in this report. However, projections of labor force separations due to death and retirement are made in Table 3-2.

Projections were made of labor force separations due to death and retirement for each field of science and engineering from 1976 to 1985. These projections are based on the tables of working life for 1970 produced by the Bureau of Labor Statistics.[4] The projections were constructed by applying the 1970 separation rates for each age/sex group to the age distribution, by sex, for each science and engineering field. Separate projections were made for the energy-related scientists and engineers.

Two general comments on the nature of these projections must be made. First, the method used in this study is essentially the same as that used by the Bureau of Labor Statistics and involves the same simplifying assumption: Separation rates differ among occupations only because of differences in the age and sex of the work forces in those occupations. Thus, the result is not a forecast that takes into account all factors affecting retirement, but rather a measure of the impact of age profiles on retirement rates. For example, the projection of a relatively large number of separations from the mining and petroleum engineering field is a function of the relatively large number of older persons working in these fields in 1976. These projections might fall short of reality for reasons not considered here (e.g., a tight labor market), but they are nevertheless useful in identifying differences among fields that can be attributed to demographic factors.

Table 3-2. Projected Separations from the Science and Engineering Labor Force, by Field, 1976-1985

Field	Total		Energy-Related	
	Number	Percent[1]	Number	Percent[1]
Scientist	69,898	20.7	6,006	23.2
Mathematician and statistician	4,199	18.4	205	25.8
Computer specialist	4,918	10.3	233	9.2
Physical scientist	24,214	22.6	2,661	25.9
Chemist	18,267	24.2	1,646	28.4
Physicist, astronomer	4,775	18.6	834	22.1
Other	1,172	21.0	181	26.6
Environmental, earth, and marine scientist	6,177	24.5	2,612	24.9
Earth scientist	5,140	24.5	2,586	24.9
Atomspheric and marine scientist	1,037	24.5	26	23.8
Life scientist	14,218	22.3	81	20.7
Psychologist	6,590	21.1	33	14.3
Social scientist	9,582	23.6	180	15.5
Economist	4,128	26.0	147	15.6
Other	5,454	22.0	33	15.0
Engineer	137,999	23.0	19,281	22.6
Chemical	9,102	26.3	2,073	25.6
Civil and architectural	18,258	23.9	1,421	25.5
Electrical and electronic	24,663	20.1	2,667	19.2
Mechanical	27,113	23.8	4,937	22.9
Metallurgical and materials	3,882	27.6	558	24.8
Mining and petroleum	2,941	29.5	1,687	25.0
Nuclear	989	19.5	714	20.6
Managerial and administrative	15,296	22.3	2,432	22.9
Environmental and sanitary	1,821	21.1	12	8.3
Operations research/systems	1,837	16.5	177	15.2
Industrial	6,066	23.9	279	17.1
Other	26,031	23.6	2,324	23.0

[1]Separations for 1976-85 as percentage of the 1976 population of scientists and engineers in the labor force.

The projections in Table 3-2 indicate considerable variations among the engineering fields. Of course, the largest number of separations tends to occur in the largest fields (e.g., mechanical engineering). However, what is most relevant here is the variation in the 10-year separation rate. It is lowest (16.5 percent) for operations research and systems engineers and highest (29.5 percent) for mining and petroleum engineers. The range is even greater among scientists: The 10-year separation rate ranges from a low of 10.3 percent for computer specialists to 26.0 percent for economists.

Comparing energy-related scientists and engineers to the total shows no consistent pattern of higher or lower separation rates. Overall, however, energy-related engineers have about the same separation rate as the total of all engineers, while energy-related scientists show a higher separation rate than do all scientists. A major reason for this overall tendency is the relatively high separation rate of earth scientists and chemists. These two fields tend to dominate the average for energy-related scientists.

NOTES

[1]The reader interested in a detailed explanation of the procedures developed at NSF for classifying scientists and engineers by professional field should consult National Science Foundation, *Characteristics of Experienced Scientists and Engineers, 1976: Detailed Statistical Tables, Appendix B*, Washington, D.C., 1978 (NSF 78-305). This publication also contains a copy of the 1976 survey questionnaire.

[2]The hypothesis that the NSF criteria were designed in such a way that they tend to exclude engineers with an MBA if they also reported that they worked as managers was tested. Specifically, those persons who reported in 1972 that they had received a bachelor's in engineering, a master's in business or commerce, and who also reported management or administration as their occupation of employment in 1972 were identified. There were 12,454 who had this combination of education and employment characteristics in 1972. Of these, 9,508 were declared "out-of-scope" in 1972 according to the NSF criteria. Those found to be out-of-scope in 1972 were not reinterviewed in 1974 or 1976.

[3]U.S. Department of Energy, Division of Manpower Assessment, *Energy-Related Doctoral Scientists and Engineers in the United States-1975*, Washington, D.C., U.S. Government Printing Office, November 1977.

[4]Howard N. Fullerton, Jr., and James J. Byrne, "Length of Working Life for Men and Women, 1970," *Monthly Labor Review* 99(2):31-35.

APPENDIX - DETAILED DATA ON EDUCATION AND TRAINING

Table A-1. On-the-Job Training, Total vs. Energy-Related Scientists and Engineers, 1975

Professional Field	Total		Energy-Related	
	Number	Percent	Number	Percent
Total, scientist and engineer	177,274		22,539	
Scientist	66,438	18.0	4,998	18.7
Physicist, astronomer	2,622	9.5	417	10.7
Earth scientist (includes geologist and geophysicist)	3,865	17.3	2,042	19.0
Engineer	110,836	16.8	17,541	19.9
Chemical	6,530	17.6	1,616	18.9
Mechanical	19,142	15.3	4,215	18.8
Metallurgical and materials	2,140	13.6	438	18.8
Mining and petroleum	1,814	16.8	1,332	18.6
Nuclear	1,240	23.0	836	23.8
Managerial and administrative	16,215	21.7	2,335	21.0

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

Table A-2. Military Training Applicable to Civilian Occupations, Total vs. Energy-Related Scientists and Engineers, 1975

Professional Field	Total		Energy-Related	
	Number	Percent	Number	Percent
Total, scientist and engineer	7,514		681	
Scientist	2,205	0.6	92	0.3
Physicist, astronomer	207	.8	13	.3
Earth scientist (includes geologist and geophysicist)	61	.3	25	.2
Engineer	5,309	.8	589	.7
Chemical	176	.5	13	.2
Mechanical	1,229	1.0	88	.4
Metallurgical and materials	35	.2		
Mining and petroleum	14	.1	14	.2
Nuclear	62	1.2		
Managerial and administrative	401	.5	49	.4

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

Table A-3. Extension or Correspondence Courses, Total vs. Energy-Related Scientists and Engineers, 1975

Professional Field	Total		Energy-Related	
	Number	Percent	Number	Percent
Total, scientist and engineer	36,049		4,194	
Scientist	12,117	3.3	705	2.6
Physicist, astronomer	903	3.3	163	4.2
Earth scientist (includes geologist and geophysicist)	662	3.0	305	2.8
Engineer	23,932	3.6	3,489	4.0
Chemical	1,265	3.4	352	4.1
Mechanical	4,075	3.3	1,016	4.5
Metallurgical and materials	529	3.4	12	.5
Mining and petroleum	276	2.6	106	1.5
Nuclear	255	4.7	138	3.9
Managerial and administrative	2,158	2.9	530	4.8

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

Table A-4. Courses at Employer's Training Facility, Total vs. Energy-Related Scientists and Engineers, 1975

Professional Field	Total		Energy-Related	
	Number	Percent	Number	Percent
Total, scientist and engineer	165,187		23,154	
Scientist	51,398	13.9	4,684	17.5
Physicist, astronomer	2,486	9.0	436	11.2
Earth scientist (includes geologist and geophysicist	3,243	14.5	2,055	19.2
Engineer	113,789	17.2	18,470	20.9
Chemical	6,415	17.3	1,584	18.5
Mechanical	20,402	16.3	3,978	17.8
Metallurgical and materials	2,225	14.2	358	15.4
Mining and petroleum	2,083	19.3	1,300	18.1
Nuclear	1,213	22.5	748	21.3
Managerial and administrative	16,448	22.0	3,085	27.7

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

Table A-5. Courses at Adult Education Center, Total vs. Energy-Related Scientists and Engineers, 1975

Professional Field	Total		Energy-Related	
	Number	Percent	Number	Percent
Total, scientist and engineer	41,904		5,170	
Scientist	14,960	4.1	1,157	4.3
Physicist, astronomer	481	1.7	24	.6
Earth scientist (includes geologist and geophysicist	1,060	4.7	568	5.3
Engineer	26,944	4.1	4,013	4.6
Chemical	1,793	4.8	359	4.2
Mechanical	4,582	3.7	1,086	4.9
Metallurgical and materials	665	4.2	153	6.6
Mining and petroleum	302	2.8	200	2.8
Nuclear	578	10.7	472	13.4
Managerial and administrative	3,549	4.8	503	4.5

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*

Table A-6. Other Training,
Total vs. Energy-Related Scientists and Engineers, 1975

Professional Field	Total		Energy-Related	
	Number	Percent	Number	Percent
Total, scientist and engineer	86,741		12,094	
Scientist	36,670	9.9	2,392	9.0
Physicist, astronomer	1,954	7.1	144	3.7
Earth scientist (includes geologist and geophysicist	1,821	8.1	1,163	10.8
Engineer	50,071	7.6	9,702	11.0
Chemical	2,541	6.8	830	9.7
Mechanical	7,341	5.9	2,296	10.3
Metallurgical and materials	1,316	8.4	166	7.1
Mining and petroleum	1,032	9.5	792	11.0
Nuclear	828	15.4	674	19.2
Managerial and administrative	8,418	11.3	1,466	13.2

Source: U. S. Bureau of the Census/NSF, *National Survey of Natural and Social Scientists and Engineers.*